



TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 000000000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 1A

TABLE OF CONTENTS

SECTION I: PROJECT OVERVIEW & PURPOSE	3
1. Aerial LiDAR Project.....	3
<i>a. Project Overview</i>	3
<i>b. Project Purpose</i>	3
<i>c. Client Contact Information</i>	4
<i>d. Contract Deliverables</i>	4
SECTION II: FIELD OPERATIONS	5
1. Aerial LiDAR Project – Aerial Acquisition	5
<i>a. Aircraft & Sensor Information</i>	5
<i>b. Sensor Acquisition Information</i>	5
<i>c. Flight Plan Execution</i>	6
<i>d. GNSS Reference Stations</i>	6
2. Aerial LiDAR Project – Ground Acquisition	8
<i>a. Ground Control Survey</i>	8
SECTION III: DATA PRODUCTION	13
3. Aerial LiDAR Project – Calibration/Classification	13
<i>a. LiDAR Point Cloud Generation</i>	13
<i>b. Coordinate Reference System</i>	13
<i>c. LiDAR Point Cloud Statistics</i>	13
<i>d. Smooth Surface Repeatability (Interswath)</i>	13
<i>e. LiDAR Calibration</i>	13
<i>f. LiDAR Classification</i>	14
<i>g. LiDAR Intensity Imagery</i>	14
<i>h. Hydro-line Collection/Conflation</i>	14
<i>i. Bare-Earth Surface – Digital Elevation Model (DEM)</i>	14
<i>j. Surface-Digital Elevation Model (DSM)</i>	14
SECTION IV: ACCURACY ASSESSMENT	15
1. Aerial LiDAR Project – Vertical Accuracy Assessment.....	15
<i>a. Requirements</i>	15
<i>b. Results</i>	15
SECTION V: CERTIFICATION STATEMENTS	16
1. Aerial LiDAR Project.....	16
SECTION VI: CONTROL POINT ASSESSMENTS	17
1. Aerial LiDAR Project.....	17
<i>a. Point Cloud Check Point Assessment</i>	17
<i>b. Digital Elevation Model (DEM) Check Point Assessment</i>	19

SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

The State of Kansas Contract 0000000000000000000039891 required Leaf-off 2018 QL 2 LiDAR surveys to be collected over 54,663 square miles covering part or all of 86 counties in Kansas in support of the Kansas Department of Agriculture and Kansas Data Access and Support Center. Aerial LiDAR data for this task order was planned, acquired, processed and produced at an aggregate nominal pulse spacing (ANPS) of 0.71 meters and in compliance with USGS National Geospatial Program LiDAR Base Specification version 1.2. Project Block 1A encompasses part or all of 9 counties in Kansas and covers approximately 3,374 square miles.

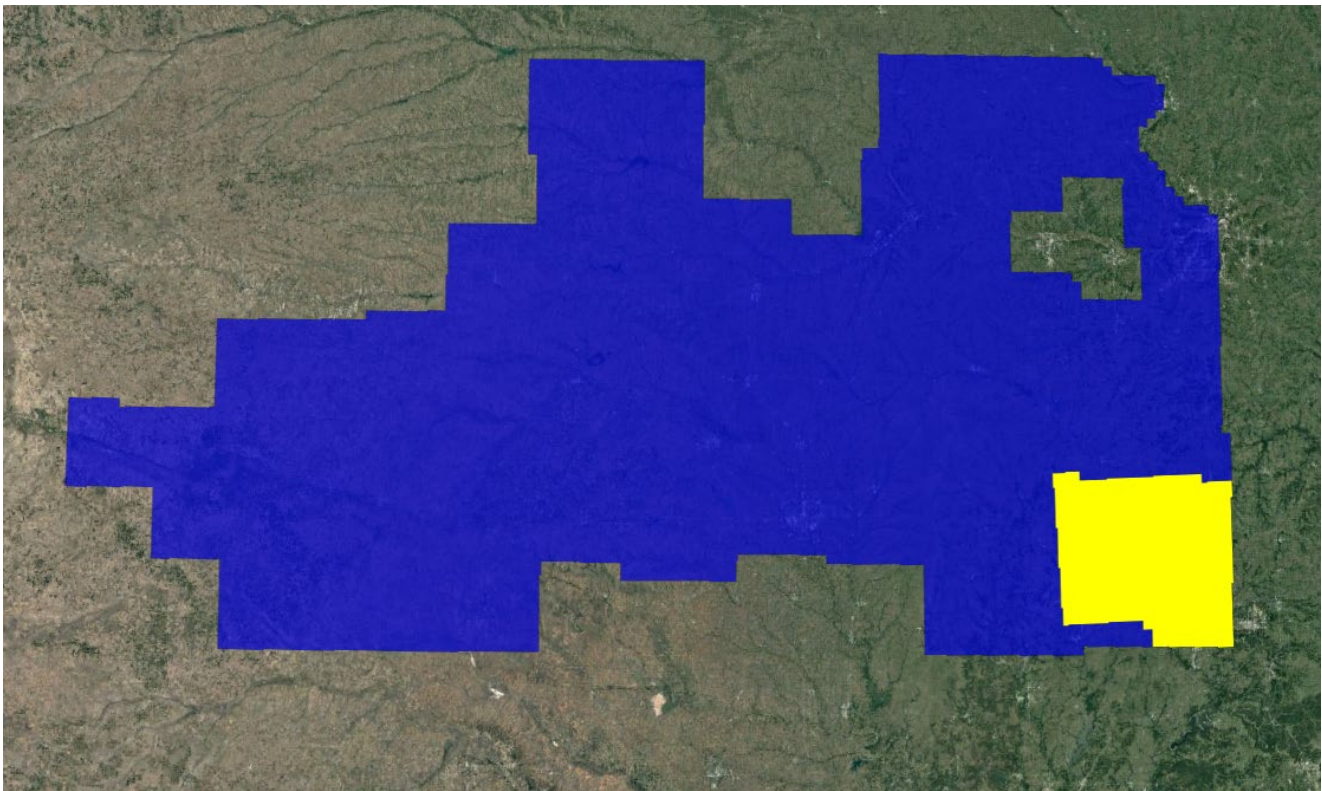


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

b. Project Purpose

The State of Kansas, on behalf of the Kansas Department of Agriculture and Kansas Data Access and Support Center, has contracted with Atlantic for professional services related to the development of Light Detection and Ranging (LiDAR). Additional partners include the USDA Natural Resource Conservation Service, the U.S. Geological Survey, the Kansas GIS Policy Board, the Kansas Department of Transportation and the Kansas Water Office. These LiDAR elevation data will be used for conservation planning, design, research, floodplain mapping, wetlands identification, dam safety assessments, hydrologic modeling, and subsidence monitoring.

c. Client Contact Information

Client Contact Information	
Name of Contact	Tara Lanzrath, CFM
Organization	Kansas Department of Agriculture
Position	Floodplain Mapping Coordinator
Telephone	785-296-2513
E-Mail Address	Tara.Lanzrath@ks.gov
Mailing Address	6531 SE Forbes Ave., Suite B
City	Topeka
State or Province	Kansas
Postal Code	66619

Table 1: Aerial LiDAR Client Contact Information

d. Contract Deliverables

Item	Specification/Format
Metadata	FGDC compliant, xml format
Project Report	.pdf format
Raw Point Cloud	Swaths, LAS 1.4
Classified Point Cloud	LAS 1.4
Bare Earth DEM	ERDAS .IMG format, Hydroflattened
First Return DSM	ERDAS .IMG format
Hydro Polygon Breaklines	.gdb format
Intensity Imagery	ERDAS .IMG format

Table 2: Aerial LiDAR Contract Deliverables

SECTION II: FIELD OPERATIONS

1. Aerial LiDAR Project – Aerial Acquisition

a. Aircraft & Sensor Information

Atlantic operated a Cessna (N732JE) outfitted with a Leica ALS70-HP LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	ALS70-HP
Manufacturer	Leica
Platform	Fixed-Wing
Scan Pattern	Sine, Triangle, Raster
Maximum Scan Rate (Hz)	Sine: 200 Triangle: 158 Raster: 120
Field of View (°)	0 – 75 (Full Angle, User Adjustable)
Maximum Pulse Rate (kHz)	500
Maximum Flying Height (m AGL)	3500
Number of Returns	Unlimited
Number of Intensity Measurements	3 (First, Second, Third)
Roll Stabilization (Automatic Adaptive, °)	75 - Active FOV
Storage Media	Removable 500 GB SSD
Storage Capacity (Hours @ Max Pulse Rate)	6
Size (cm)	Scanner: 37 W x 68 L x 26 H Control Electronics: 45 W x 47 D x 36 H
Weight (kg)	Scanner: 43 Control Electronics: 45
Operation Temperature (°C)	0 – 40
Flight Management	FCMS
Power Consumption	927 @ 22.0 – 30.3 VDC

Table3: System Specifications – ALS70-HP

b. Sensor Acquisition Information

The following table illustrates project specific system parameters for LiDAR acquisition on this project:

Parameter	Specification
System	Leica ALS70-HP
Nominal Pulse Spacing (m)	0.71
Nominal Pulse Density (pls/m²)	2.2
Nominal Flight Height (AGL meters)	2000
Nominal Flight Speed (kts)	130
Pass Heading (°)	0
Sensor Scan Angle (°)	45
Scan Frequency (Hz)	33.9
Pulse Rate of Scanner (kHz)	256,400
Line Spacing (m)	1,171

Parameter	Specification
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	.35
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	2
Beam Divergence (mrad)	.15
Nominal Swath Width (m)	1,740
Nominal Swath Overlap (%)	20
Scan Pattern	TRIANGLE

Table 4: Aerial LiDAR Sensor Acquisition Parameters

c. Flight Plan Execution

Atlantic acquired 124 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 10 flight missions conducted between January 2, 2018 and January 25, 2018. Onboard differential Global Navigation Satellite System (GNSS) unit(s) recorded sample aircraft positions at 2 hertz (Hz) or more frequency. LiDAR data was only acquired when a minimum of six (6) satellites were in view.

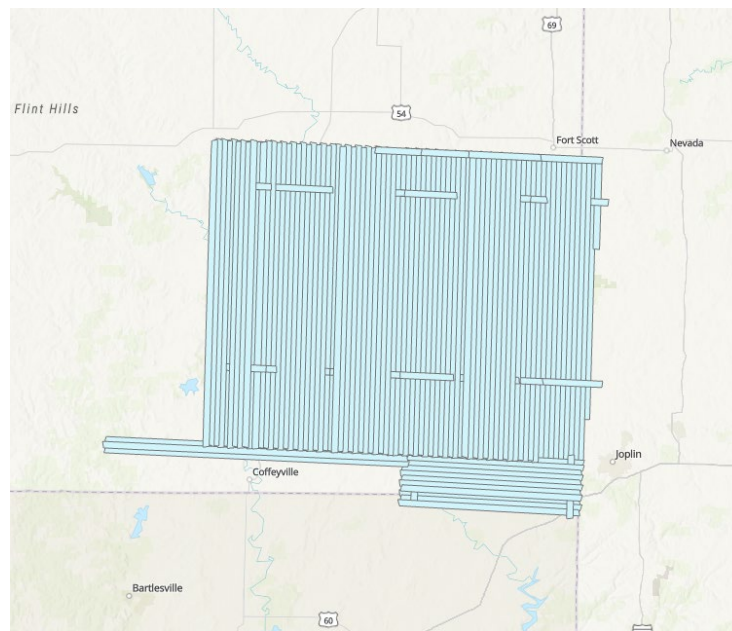


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Nine (9) Continuously Operating Reference Stations (CORS) were used to control the LiDAR acquisition for the defined project area. The coordinates provided in below are in NAD83 (2011), Geographic Coordinate System, Ellipsoid, Meters.

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
ICT3	CORS	ICT3	37°45'09.33297"	97°12'58.42230"	401.242
KSBU	CORS	KSBU	38°11'44.87410"	95°44'17.05409"	291.002
KSCP	CORS	KSCP	38°58'16.52297"	97°01'11.87249"	321.566
KSEU	CORS	KSEU	37°51'06.27235"	96°17'23.73014"	345.374

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
MOA2	CORS	MOA2	36°41'03.41544"	94°26'18.28447"	268.313
MOCA	CORS	MOCA	37°10'39.18857"	94°21'27.28200"	269.942
MONE	CORS	MONE	37°51'56.74271"	94°20'58.40827"	221.254
MOSB	CORS	MOSB	38°49'48.71034"	94°32'04.48758"	301.135
ZKC1	CORS	ZKC1	38°52'48.57351"	94°47'27.00464"	305.466

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 97 ground survey points were collected in support of this project, including 16 LiDAR Control Points (LCP), 45 Non-vegetated Vertical Accuracy (NVA) and 36 Vegetated Vertical Accuracy (VVA).

Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from LiDAR points in clear and open areas. A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of five (5) times the Nominal Pulse Spacing (NPS) exists with less than 1/3 of the RMSEZ deviation from a low-slope plane. Slopes that exceed ten (10) percent were avoided.

Each land cover type representing ten (10) percent or more of the total project area were tested and reported with a VVA. In land cover categories other than dense urban areas, the tested points did not have obstructions forty-five (45) degrees above the horizon to ensure a satisfactory TIN surface. The VVA value is provided as a target. It is understood that in areas of dense vegetation, swamps, or extremely difficult terrain, this value may be exceeded.

The NVA value is a requirement that must be met, regardless of any allowed “busts” in the VVA(s) for individual land cover types within the project. Checkpoints for each assessment (NVA & VVA) are required to be well-distributed throughout the land cover type, for the entire project area.

The following tables and figures outline the coordinate values and distribution of LCP, NVA and VVA points collected in support of this project:

ID	Easting	Northing	Elevation
LCP08	345237.9710	4101648.5850	252.4230
LCP09	348446.2350	4111408.0280	259.7500
LCP11	337941.9750	4145213.9610	298.1430
LCP117	285106.4550	4163681.0550	308.0180
LCP122	307122.8810	4141284.0320	284.4770
LCP123	297649.3710	4126615.7270	275.9610
LCP125	310205.5780	4126614.2380	263.3440
LCP126	326300.6690	4127448.3430	274.5790
LCP127	298659.0020	4115069.8360	265.3310
LCP130	355398.5950	4096230.7290	310.5780
LCP139	309266.1810	4163838.1310	298.0390
LCP141	305505.0530	4112128.5550	261.0470
LCP145	322949.8840	4182844.4590	285.4310
LCP146	306954.3580	4159031.5740	289.6850
LCP46	333791.0800	4185875.7550	281.2900
LCP47	329710.2350	4180286.5160	294.1420

Table 6: LiDAR Control Point Coordinates

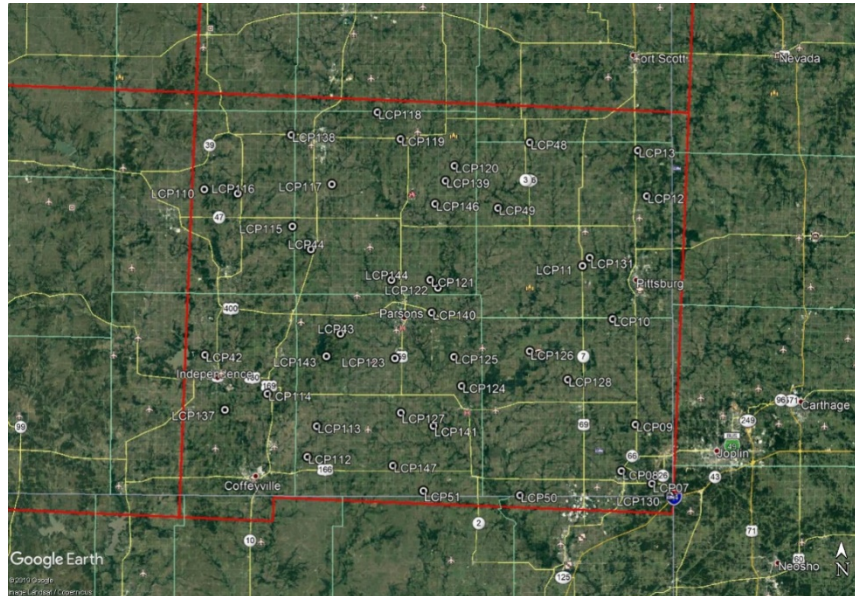


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA130	300201.8550	4120318.3110	270.0740
NVA132	261336.8210	4123116.4230	233.0280
NVA136	297297.0400	4143143.0880	284.8920
NVA137	295563.8530	4165778.9590	290.3500
NVA142	322946.5650	4182865.0770	285.9600
NVA143	331865.3740	4168234.5790	306.4840
NVA144	318328.9540	4140231.9580	272.6820
NVA145	322986.6290	4121414.9480	260.2450
NVA146	331390.4330	4109853.0130	266.4480
NVA149	327502.7180	4105260.9970	260.0080
NVA162	348343.3460	4106746.7440	257.6240
NVA163	348939.5720	4133722.4780	277.0030
NVA164	337306.9920	4159955.6240	305.5280
NVA166	355384.1770	4096241.3450	310.1170
NVA17	351962.3990	4159643.5780	281.4260
NVA18	337950.3490	4145214.1410	298.0820
NVA19	348447.2220	4111418.1500	259.7380
NVA209	260615.2820	4174616.2860	271.7050
NVA21	345250.2770	4101616.2580	252.2490
NVA211	262593.5790	4146438.6590	251.8440
NVA212	309645.1200	4176904.0430	314.7970

ID	Easting	Northing	Elevation
NVA213	309279.0540	4163814.5660	297.8850
NVA214	300091.5440	4154305.0670	271.0430
NVA216	305654.3690	4136065.3030	293.1210
NVA217	270108.6930	4142258.5530	279.2090
NVA220	318600.3490	4115036.7270	252.6090
NVA221	321657.9840	4134685.1880	269.7290
NVA222	325590.3090	4178392.6920	282.6030
NVA226	312710.5360	4102275.9100	252.0770
NVA227	344725.2580	4094837.2690	253.3270
NVA228	346566.9130	4153290.6380	293.9740
NVA236	283355.1180	4157620.7360	305.1090
NVA238	312105.3650	4146510.3820	261.0760
NVA239	323951.8770	4114906.2920	252.0980
NVA242	300853.5850	4188249.5890	327.3390
NVA60	285103.1260	4163670.4280	307.8790
NVA62	305557.2070	4142999.3810	287.4900
NVA64	297641.3110	4126615.8700	276.0930
NVA67	298663.7240	4115068.1790	265.3790
NVA68	333778.6570	4185873.9980	280.8580
NVA71	326308.5730	4127449.3270	274.2010
NVA72	311714.2380	4120429.8810	257.1020
NVA91	345620.8390	4183913.3310	251.7890
NVA92	339513.3330	4146870.9790	285.2100
NVA95	337126.3190	4099860.4290	265.6030

Table 7: Non-Vegetated Vertical Accuracy (NVA) Point Coordinates

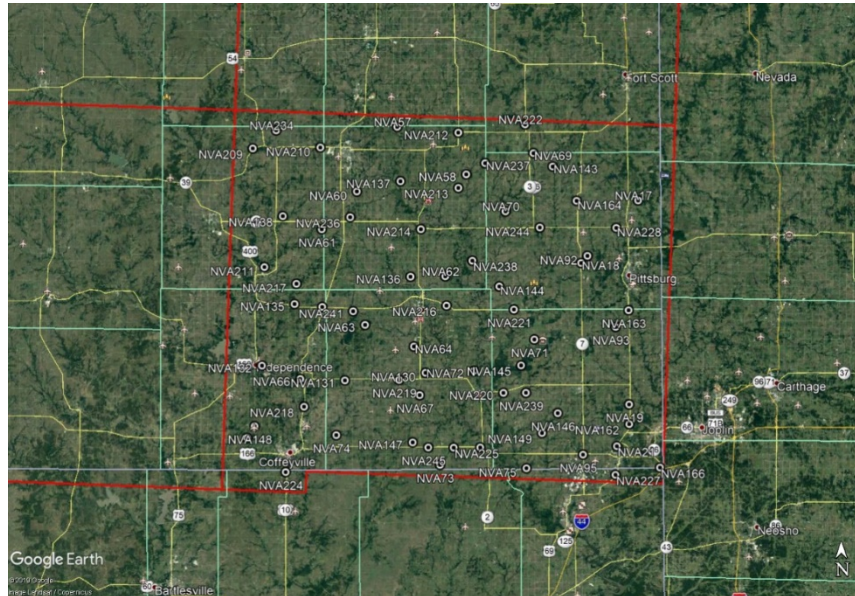


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA103	346576.5190	4153310.4090	293.6220
VVA105	344726.5350	4094844.9910	253.2410
VVA106	337241.2840	4104810.2680	272.6580
VVA13	344084.4000	4133819.1060	271.4730
VVA132	261193.6230	4116511.0410	233.9470
VVA135	265004.5050	4162182.9940	273.1420
VVA136	283338.9190	4157616.7670	305.1560
VVA137	295556.0130	4165642.4100	293.5580
VVA14	350301.1270	4169304.9920	289.4260
VVA142	315764.8350	4169476.1430	314.1430
VVA143	323961.2130	4114924.2070	252.3840
VVA146	348974.6190	4133732.5790	275.8380
VVA147	337296.5760	4159945.0060	305.0780
VVA15	341812.0390	4182488.8560	281.7120
VVA158	309640.7060	4176921.0790	313.7660
VVA159	321669.9340	4134638.6900	269.1260
VVA160	318589.1810	4115047.2790	252.5790
VVA162	261299.8780	4123110.6920	235.0940
VVA163	270127.6450	4142239.3650	280.1310
VVA164	304805.5150	4181676.7450	310.6520
VVA165	300095.3990	4154287.1940	270.2320

ID	Easting	Northing	Elevation
VVA166	312742.4480	4102264.3660	251.8070
VVA17	351698.5000	4098826.8230	281.3190
VVA39	299902.8490	4172859.1710	306.6610
VVA41	280354.7940	4150050.0270	316.3010
VVA42	307141.7500	4141296.9580	285.1390
VVA43	310214.4380	4126617.1900	263.6840
VVA45	280697.1460	4112624.2830	231.3510
VVA46	334262.8490	4121216.8800	266.9730
VVA47	329702.0910	4180264.0140	294.0200
VVA57	341747.5980	4174004.1260	300.5870
VVA81	305519.3870	4112117.3700	260.9110
VVA88	296973.0300	4183549.1740	313.4690
VVA89	317636.2450	4185434.9040	308.1210
VVA90	328358.1520	4153892.1150	288.9570
VVA94	322632.9520	4106285.0680	246.9280

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

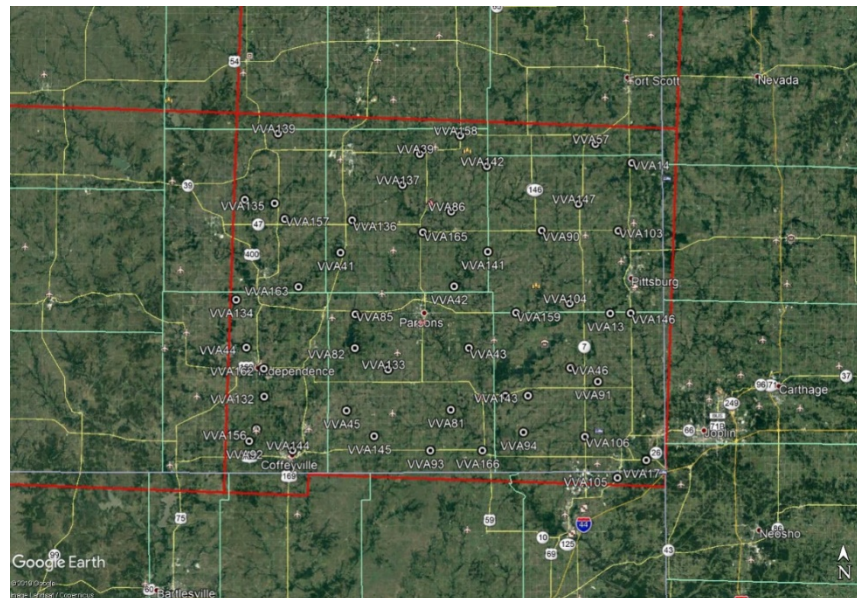


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION III: DATA PRODUCTION

3. Aerial LiDAR Project – Calibration/Classification

a. LiDAR Point Cloud Generation

Atlantic used Leica software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Waypoint Inertial Explorer is used to extract the raw IPAS ABGNSS/IMU data, which is further processed in combination with controlled base stations to provide the final Smoothed Best Estimate Trajectory (SBET) for each mission. The SBETs are combined with the raw laser scan files to export the LiDAR ASCII Standard (*.las) formatted swath point clouds.

b. Coordinate Reference System

Horizontal Datum: NAD83 2011 (HARN)
Coordinate System: UTM, 15N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points	26,169,439,849
Nominal Pulse Spacing (m)	0.6139
Nominal Pulse Density (pls/m²)	2.6538
Aggregate Total Points	26,169,439,849
Aggregate Nominal Pulse Spacing (m)	0.6040
Aggregate Nominal Pulse Density (pls/m²)	2.7408

Table 9: LiDAR Point Cloud Statistics

d. Smooth Surface Repeatability (Interswath)

Departures from planarity of first returns within single swaths in non-vegetated areas were assessed at multiple locations with hard surface areas (parking lots or large rooftops) inside the project area. Each area was evaluated using signed difference rasters (maximum elevation – minimum elevation) at a cell size equal to 2 x ANPS, rounded to the next integer.

e. LiDAR Calibration

Using a combination of GeoCue, TerraScan and TerraMatch; overlapping swath point clouds are corrected for any orientation or linear deviations to obtain the best fit swath-to-swath calibration. Relative calibration was evaluated using advanced plane-matching analysis and parameter corrections derived. This process was repeated interactively until residual errors between overlapping swaths, across all project missions, was reduced to ≤2cm. A final analysis of the calibrated lidar is performed using a TerraMatch tie line report for an overall statistical model of the project area. Individual control point assessments for this project can be found in Section VI of this report.

Upon completion of the data calibration, a complete set of elevation difference intensity rasters (dZ Orthos) are produced. A user-defined color ramp is applied depicting the offsets between overlapping swaths based on project specifications. The dZ orthos provide an opportunity to review the data calibration in a qualitative

manner. Atlantic assigns green to all offset values that fall below the required RMSDz requirement of the project. A yellow color is assigned for offsets that fall between the RMSDz value and 1.5x of that value. Finally, red values are assigned to all values that fall beyond 1.5x of the RMSDz requirements of the project.

f. LiDAR Classification

Multiple automated filtering routines are applied to the calibrated LiDAR point cloud identifying and extracting bare-earth and above ground features. GeoCue, TerraScan, and TerraModeler software was used for the initial batch processing, visual inspection and any manual editing of the LiDAR point clouds. Atlantic utilized collected breakline data to preform classification for classes 9 (Water) and 10 (Ignored Ground).

Code	Description
1	Unclassified
2	Ground
7	Low point (noise)
9	Water
10	Ignored ground (breakline proximity)
17	Bridge
18	High point (noise)

Table 10: LiDAR Point Classification Codes and Descriptions

g. LiDAR Intensity Imagery

LiDAR intensity imagery was created from the final calibrated and classified lidar point cloud. Intensity images were produced from all classified points and posted to a 0.5-meter cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in .img format.

h. Hydro-line Collection/Conflation

Hydro breaklines were compiled using LiDAR intensity data and surface terrain models of the entire project area. After the collection, all delineated hydro features were validated for monotonicity and vertical variance. This procedure ensures that no points were floating above ground. Hydro-lines were then encoded into the LiDAR surface and used to hydro-enforce/flatten all significant water bodies. These final hydro-lines were then used in the production of bare Earth digital models to hydro flatten significant water bodies. This product was delivered as an ESRI geodatabase for the entire project area.

i. Bare-Earth Surface – Digital Elevation Model (DEM)

Bare earth Digital Elevation Models (DEMs) were derived using the hydro-lines and bare earth (ground) LiDAR points. All DEMs were created with a grid spacing of 1 meter. DEMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .img format.

j. Surface-Digital Elevation Model (DSM)

Surface digital elevation models (DSMs) were derived using all first return LiDAR points, excluding LiDAR points classified as high or low noise. All DSMs were created with a grid spacing of 1 meter. DSMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .img format.

SECTION IV: ACCURACY ASSESSMENT

1. Aerial LiDAR Project – Vertical Accuracy Assessment

a. Requirements

Per the table below, the Vertical Accuracy Assessment utilized the required parameters for Vertical Data Accuracy Class IV.

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95 th Percentile (cm)
I	1.0	2.0	2.9
II	2.5	4.9	7.4
III	5.0	9.8	14.7
IV	10.0	19.6	29.4
V	12.5	24.5	36.8
VI	20.0	39.2	58.8
VII	33.3	65.3	98.0
VIII	66.7	130.7	196.0
IX	100.0	196.0	294.0
X	333.3	653.3	980.0

Table 11: Vertical Accuracy Standards, Source: ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014)

*The terms NVA and VVA are from the American Society for Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014). The term NVA refers to assessments in clear, open areas (which typically produce only single LiDAR returns); the term VVA refers to assessments in vegetated areas (typically characterized by multiple return LiDAR).

b. Results

An overall statistical assessment of the check points can be found in the following two tables (values provided in meters):

Broad Land Cover Type	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	43	0.0918	0.1800	0.1559
NVA (DEM)	43	0.0976	0.1912	0.1343
VVA (Point Cloud)	36	0.1907	0.3738	0.2955
VVA (DEM)	36	0.1760	0.3451	0.2658

Table 12: NVA/VVA Accuracies

SECTION V: CERTIFICATION STATEMENTS

1. Aerial LiDAR Project

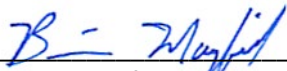
This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was not intended to meet specifications and/or requirements of users outside of the United States Geological Survey.

It should also be noted that LiDAR points do not represent a continuous surface model. LiDAR points are discrete measurements of the surface and any values derived within a triangle of three LiDAR points are interpolated. As such, the user should not use the resultant LiDAR dataset for vertical placement of a planimetric feature such as a headwall, building footprint or any other planimetric feature unless there is an associated LiDAR point that can be reasonably located on this structure.

Consideration should be given by the end user of this dataset to the fact that this LiDAR dataset was developed differently and separately than previous LiDAR datasets that may be available for this geographic location. It is likely that the data in this project was created using different geodetic control, a different Geoid, newer LiDAR technology and more up-to-date processing techniques. As such, any direct comparative analysis performed between this dataset and previous datasets could result in misleading or inaccurate results. Users are encouraged to proceed with caution while performing this type of comparative analysis and to completely understand the variables that make each of these datasets unique and not corollary.

It is encouraged that the user refers to the full FGDC Metadata and project reports for a complete understanding on the content of this dataset.

I, hereby, certify to the extent of my knowledge that the statements and statistics represented in this document are true and factual.



Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276



SECTION VI: CONTROL POINT ASSESSMENTS

1. Aerial LiDAR Project

a. Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA211	262593.579	4146438.659	251.844	265.3210	-0.0100	NVA
NVA221	321657.984	4134685.188	269.729	298.0910	0.0520	NVA
NVA149	327502.718	4105260.997	260.008	281.3540	0.0640	NVA
NVA164	337306.992	4159955.624	305.528	285.5030	0.0720	NVA
NVA21	345250.277	4101616.258	252.249	275.8820	-0.0790	NVA
NVA214	300091.544	4154305.067	271.043	252.3330	-0.0900	NVA
NVA71	326308.573	4127449.327	274.201	307.9220	-0.0960	NVA
NVA213	309279.054	4163814.566	297.885	310.4780	-0.1000	NVA
NVA236	283355.118	4157620.736	305.109	263.4470	0.1030	NVA
NVA95	337126.319	4099860.429	265.603	294.2510	0.1090	NVA
NVA145	322986.629	4121414.948	260.245	298.2590	0.1160	NVA
NVA222	325590.309	4178392.692	282.603	289.8030	0.1180	NVA
NVA242	300853.585	4188249.589	327.339	259.8690	0.1190	NVA
NVA227	344725.258	4094837.269	253.327	261.1690	0.1220	NVA
NVA212	309645.12	4176904.043	314.797	274.7020	0.1230	NVA
NVA130	300201.855	4120318.311	270.074	284.6040	0.1270	NVA
NVA67	298663.724	4115068.179	265.379	251.8450	0.0010	NVA
NVA239	323951.877	4114906.292	252.098	269.7430	0.0140	NVA
NVA68	333778.657	4185873.998	280.858	259.9910	-0.0170	NVA
NVA220	318600.349	4115036.727	252.609	305.5450	0.0170	NVA
NVA18	337950.349	4145214.141	298.082	252.2280	-0.0210	NVA
NVA142	322946.565	4182865.077	285.96	271.0200	-0.0230	NVA
NVA238	312105.365	4146510.382	261.076	274.2240	0.0230	NVA
NVA166	355384.177	4096241.345	310.117	297.9090	0.0240	NVA
NVA146	331390.433	4109853.013	266.448	305.0840	-0.0250	NVA
NVA64	297641.311	4126615.87	276.093	265.5780	-0.0250	NVA
NVA217	270108.693	4142258.553	279.209	260.2710	0.0260	NVA
NVA228	346566.913	4153290.638	293.974	282.5770	-0.0260	NVA
NVA163	348939.572	4133722.478	277.003	327.3120	-0.0270	NVA
NVA72	311714.238	4120429.881	257.102	253.2960	-0.0310	NVA
NVA226	312710.536	4102275.91	252.077	314.8300	0.0330	NVA
NVA162	348343.346	4106746.744	257.624	270.0370	-0.0370	NVA
NVA62	305557.207	4142999.381	287.49	265.3270	-0.0520	NVA
NVA137	295563.853	4165778.959	290.35	252.1520	0.0540	NVA
NVA17	351962.399	4159643.578	281.426	280.9120	0.0540	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA60	285103.126	4163670.428	307.879	252.6740	0.0650	NVA
NVA136	297297.04	4143143.088	284.892	298.1540	0.0720	NVA
NVA216	305654.369	4136065.303	293.121	286.0360	0.0760	NVA
NVA143	331865.374	4168234.579	306.484	261.1560	0.0800	NVA
NVA92	339513.333	4146870.979	285.21	310.0360	-0.0810	NVA
NVA91	345620.839	4183913.331	251.789	266.5320	0.0840	NVA
NVA19	348447.222	4111418.15	259.738	276.0090	-0.0840	NVA
NVA144	318328.954	4140231.958	272.682	279.3120	0.1030	NVA
VVA94	322632.952	4106285.068	246.928	294.0770	0.1030	VVA
VVA88	296973.03	4183549.174	313.469	277.1120	0.1090	VVA
VVA165	300095.399	4154287.194	270.232	257.2110	0.1090	VVA
VVA105	344726.535	4094844.991	253.241	251.9630	-0.1140	VVA
VVA39	299902.849	4172859.171	306.661	257.7400	0.1160	VVA
VVA143	323961.213	4114924.207	252.384	287.6090	0.1190	VVA
VVA106	337241.284	4104810.268	272.658	290.2260	-0.1240	VVA
VVA17	351698.5	4098826.823	281.319	281.5580	0.1320	VVA
VVA166	312742.448	4102264.366	251.807	307.7450	-0.1340	VVA
VVA137	295556.013	4165642.41	293.558	284.7500	-0.1420	VVA
VVA147	337296.576	4159945.006	305.078	293.2640	0.1430	VVA
VVA159	321669.934	4134638.69	269.126	306.6320	0.1480	VVA
VVA160	318589.181	4115047.279	252.579	285.3650	0.1550	VVA
VVA163	270127.645	4142239.365	280.131	251.9450	0.1560	VVA
VVA135	265004.505	4162182.994	273.142	259.9030	0.1650	VVA
VVA90	328358.152	4153892.115	288.957	272.8490	0.1670	VVA
VVA136	283338.919	4157616.767	305.156	246.9180	-0.0100	VVA
VVA43	310214.438	4126617.19	263.684	313.4810	0.0120	VVA
VVA14	350301.127	4169304.992	289.426	270.2550	0.0230	VVA
VVA142	315764.835	4169476.143	314.143	253.2090	-0.0320	VVA
VVA158	309640.706	4176921.079	313.766	306.6930	0.0320	VVA
VVA164	304805.515	4181676.745	310.652	252.3460	-0.0380	VVA
VVA81	305519.387	4112117.37	260.911	272.6980	0.0400	VVA
VVA89	317636.245	4185434.904	308.121	281.3770	0.0580	VVA
VVA103	346576.519	4153310.409	293.622	251.7480	-0.0590	VVA
VVA42	307141.75	4141296.958	285.139	293.4630	-0.0950	VVA
VVA146	348974.619	4133732.579	275.838	305.1830	0.1050	VVA
VVA15	341812.039	4182488.856	281.712	269.2310	0.1050	VVA
VVA46	334262.849	4121216.88	266.973	252.6990	0.1200	VVA
VVA13	344084.4	4133819.106	271.473	280.2680	0.1370	VVA
VVA47	329702.091	4180264.014	294.02	272.9980	-0.1440	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
VVA57	341747.598	4174004.126	300.587	289.1070	0.1500	VVA
VVA162	261299.878	4123110.692	235.094	305.3120	0.1560	VVA
VVA45	280697.146	4112624.283	231.351	263.8430	0.1590	VVA
VVA132	261193.623	4116511.041	233.947	289.5880	0.1620	VVA
VVA41	280354.794	4150050.027	316.301	314.3090	0.1660	VVA

Table 13: Point Cloud Check Point Assessment

b. Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA130	300201.8550	4120318.3110	270.0740	270.0315	0.0425	NVA
NVA136	297297.0400	4143143.0880	284.8920	284.7411	0.1509	NVA
NVA137	295563.8530	4165778.9590	290.3500	290.2461	0.1039	NVA
NVA142	322946.5650	4182865.0770	285.9600	286.0426	-0.0826	NVA
NVA143	331865.3740	4168234.5790	306.4840	306.6194	-0.1354	NVA
NVA144	318328.9540	4140231.9580	272.6820	272.8646	-0.1826	NVA
NVA145	322986.6290	4121414.9480	260.2450	260.1623	0.0827	NVA
NVA146	331390.4330	4109853.0130	266.4480	266.5595	-0.1115	NVA
NVA149	327502.7180	4105260.9970	260.0080	259.9450	0.0630	NVA
NVA162	348343.3460	4106746.7440	257.6240	257.7431	-0.1191	NVA
NVA163	348939.5720	4133722.4780	277.0030	277.1257	-0.1227	NVA
NVA164	337306.9920	4159955.6240	305.5280	305.5285	-0.0005	NVA
NVA166	355384.1770	4096241.3450	310.1170	310.0148	0.1022	NVA
NVA17	351962.3990	4159643.5780	281.4260	281.5614	-0.1354	NVA
NVA18	337950.3490	4145214.1410	298.0820	298.1919	-0.1099	NVA
NVA19	348447.2220	4111418.1500	259.7380	259.8996	-0.1616	NVA
NVA21	345250.2770	4101616.2580	252.2490	252.1766	0.0724	NVA
NVA211	262593.5790	4146438.6590	251.8440	251.8419	0.0021	NVA
NVA212	309645.1200	4176904.0430	314.7970	314.8490	-0.0520	NVA
NVA213	309279.0540	4163814.5660	297.8850	297.9066	-0.0216	NVA
NVA214	300091.5440	4154305.0670	271.0430	270.9867	0.0563	NVA
NVA216	305654.3690	4136065.3030	293.1210	293.2615	-0.1405	NVA
NVA217	270108.6930	4142258.5530	279.2090	279.2648	-0.0558	NVA
NVA220	318600.3490	4115036.7270	252.6090	252.6655	-0.0565	NVA
NVA221	321657.9840	4134685.1880	269.7290	269.7267	0.0023	NVA
NVA222	325590.3090	4178392.6920	282.6030	282.5837	0.0193	NVA
NVA226	312710.5360	4102275.9100	252.0770	251.9062	0.1708	NVA
NVA227	344725.2580	4094837.2690	253.3270	253.2964	0.0306	NVA
NVA228	346566.9130	4153290.6380	293.9740	294.0707	-0.0967	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA236	283355.1180	4157620.7360	305.1090	305.0670	0.0420	NVA
NVA238	312105.3650	4146510.3820	261.0760	261.1417	-0.0657	NVA
NVA239	323951.8770	4114906.2920	252.0980	252.1754	-0.0774	NVA
NVA242	300853.5850	4188249.5890	327.3390	327.3070	0.0320	NVA
NVA60	285103.1260	4163670.4280	307.8790	307.7413	0.1377	NVA
NVA62	305557.2070	4142999.3810	287.4900	287.6117	-0.1217	NVA
NVA64	297641.3110	4126615.8700	276.0930	276.0299	0.0631	NVA
NVA67	298663.7240	4115068.1790	265.3790	265.3055	0.0735	NVA
NVA68	333778.6570	4185873.9980	280.8580	280.8912	-0.0332	NVA
NVA71	326308.5730	4127449.3270	274.2010	274.2359	-0.0349	NVA
NVA72	311714.2380	4120429.8810	257.1020	257.2043	-0.1023	NVA
NVA91	345620.8390	4183913.3310	251.7890	251.9523	-0.1633	NVA
NVA92	339513.3330	4146870.9790	285.2100	285.3599	-0.1499	NVA
NVA95	337126.3190	4099860.4290	265.6030	265.5820	0.0210	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA103	346576.5190	4153310.4090	293.6220	293.8159	-0.1939	VVA
VVA105	344726.5350	4094844.9910	253.2410	253.2150	0.0260	VVA
VVA106	337241.2840	4104810.2680	272.6580	272.6796	-0.0216	VVA
VVA13	344084.4000	4133819.1060	271.4730	271.7143	-0.2413	VVA
VVA132	261193.6230	4116511.0410	233.9470	233.6286	0.3184	VVA
VVA135	265004.5050	4162182.9940	273.1420	273.0252	0.1168	VVA
VVA136	283338.9190	4157616.7670	305.1560	305.1920	-0.0360	VVA
VVA137	295556.0130	4165642.4100	293.5580	293.4279	0.1301	VVA
VVA14	350301.1270	4169304.9920	289.4260	289.5908	-0.1648	VVA
VVA142	315764.8350	4169476.1430	314.1430	314.3003	-0.1573	VVA
VVA143	323961.2130	4114924.2070	252.3840	252.3235	0.0605	VVA
VVA146	348974.6190	4133732.5790	275.8380	276.0318	-0.1938	VVA
VVA147	337296.5760	4159945.0060	305.0780	305.1837	-0.1057	VVA
VVA15	341812.0390	4182488.8560	281.7120	281.9452	-0.2332	VVA
VVA158	309640.7060	4176921.0790	313.7660	313.9266	-0.1606	VVA
VVA159	321669.9340	4134638.6900	269.1260	269.2308	-0.1048	VVA
VVA160	318589.1810	4115047.2790	252.5790	252.6390	-0.0600	VVA
VVA162	261299.8780	4123110.6920	235.0940	234.8304	0.2636	VVA
VVA163	270127.6450	4142239.3650	280.1310	280.2694	-0.1384	VVA
VVA164	304805.5150	4181676.7450	310.6520	310.8332	-0.1812	VVA
VVA165	300095.3990	4154287.1940	270.2320	270.2271	0.0049	VVA
VVA166	312742.4480	4102264.3660	251.8070	251.7386	0.0684	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA17	351698.5000	4098826.8230	281.3190	281.4026	-0.0836	VVA
VVA39	299902.8490	4172859.1710	306.6610	306.7020	-0.0410	VVA
VVA41	280354.7940	4150050.0270	316.3010	316.7311	-0.4301	VVA
VVA42	307141.7500	4141296.9580	285.1390	285.3333	-0.1943	VVA
VVA43	310214.4380	4126617.1900	263.6840	263.7928	-0.1088	VVA
VVA45	280697.1460	4112624.2830	231.3510	231.0786	0.2724	VVA
VVA46	334262.8490	4121216.8800	266.9730	267.1206	-0.1476	VVA
VVA47	329702.0910	4180264.0140	294.0200	294.2378	-0.2178	VVA
VVA57	341747.5980	4174004.1260	300.5870	300.8873	-0.3003	VVA
VVA81	305519.3870	4112117.3700	260.9110	261.1011	-0.1901	VVA
VVA88	296973.0300	4183549.1740	313.4690	313.4886	-0.0196	VVA
VVA89	317636.2450	4185434.9040	308.1210	308.2890	-0.1680	VVA
VVA90	328358.1520	4153892.1150	288.9570	289.0918	-0.1348	VVA
VVA94	322632.9520	4106285.0680	246.9280	246.9038	0.0242	VVA

Table 14: DEM Check Point Assessment